5.0 AMENDMENT 1
TO
SITE SAFETY PLAN
PRE-DESIGN SITE INVESTIGATION
AMERICAN CHEMICAL SERVICE, INC.
GRIFFITH, INDIANA
July 1996 Update

5.1.1 INTRODUCTION

This Site Safety Plan (SSP) amendment has been prepared to supplement the Pre-Design Site Investigation, American Chemical Service, Inc. (ACS) SSP (referred to hereafter as the original SSP) developed in August 1995 for field activities at the ACS site in Griffith, Indiana. This amendment is designed to provide site-specific information for the protection of field team members during the Perimeter Groundwater Containment System (PGCS) construction. Field team members for the construction activities will follow the original SSP, except where noted in this amendment and listed below.

5.1.2 CONSTRUCTION TEAM MEMBERS

The organizational structure for the RA activities at the ACS Site has been designed to facilitate communication and reporting during the execution of construction activities at the site. The key personnel tasked with quality control and oversight of construction activities for the PGCS system are listed below.

Title	Name
Principal-In-Charge	Mr. Joe Adams
Engineering and Project Manager	Mr. Ron Schlicher
Site Manager	Mr. Todd Lewis
Construction Superintendent	Mr. Ben McGeachy
On-Site Safety Officer	Mr. Lee Orosz
Construction Quality Assurance Manager	Mr. Joe Willich

The primary responsibilities of the above-listed individuals are summarized below.

Principal-In-Charge

The Principal-In-Charge will act as the primary liaison between ACS, U.S. EPA, IDEM, and Montgomery Watson and its subcontractors. The Principal-In-Charge will be directly responsible for the contractual committments, assuring that the necessary resources are dedicated to the project, and for the overall project quality. The Principal-In-Charge will review all pertinent documents and submittals which are part of the RD/RA work at the ACS Site, and approve all change orders or modifications to the project scope of work. The Principal-In-Charge will also certify that information contained in submissions is true accurate and complete.

Engineering and Project Manager

The Engineering and Project Manager will be responsible for the successful execution and administration of all engineering-related activities. Primary engineering responsibilities include development of adequate construction documents, securing the required permits, shop drawing review, as-built drawing development, and overall conformance to the applicable regulations and work controlling documents. Project managment responsiblities include generating and updating the cost, schedule, and performance reports, and providing input to the Principal-In-Charge on an as-needed basis. The Engineering and Project Manager will be the main liaison between the field teams and office-support teams during the construction phase, and will also be responsible for approving the project-specific documents, task deliverables, and work plans as well as authorizing assignment to the project team members, approving construction change orders, and establishing and enforcing work element milestones for timely completion of RA work.

Site Manager

The Site Manager is responsible for (1) successful execution and administration of all construction activities related to the ACS Site, (2) ensuring that all construction activities proceed in accordance with the approved construction documents, (3) ensuring that all field activities are conducted in compliance with the applicable regulatory and health and safety requirements, (4) collecting all pertinent information specified in the construction documents for submittal to the Engineering and Project Manager, (5) resolving site

problems and informing the Engineering and Project Manager of the same, (6) approve/disapprove all material and labor costs for field work, (7) negotiate construction change orders, and (8) review all field data.

Construction Superintendent

The Construction Superintendent is responsible for the overall direction of the field team. The Construction Superintendent is also responsible for ensuring contractual compliance through implementation of the practices and procedures described in the contract documents, for supervision/field inspection functions, and for facilitation and integration of field activities. The Construction Superintendent will report directly to the Engineering and Project Manager.

On-Site Safety Officer

The On-Site Safety Officer is responsible for ensuring that the construction activities are in compliance with the approved Health and Safety Plan. The On-Site Safety Officer will hold tailgate meetings and keep the field team members informed of the site hazards. The On-Site Safety Officer will report to the Site Manager.

Construction Quality Assurance (CQA) Manager

The CQA Manager is responsible for observing and documenting activities related to the completion of the RA. The CQA Manager will observe and document work completed at the site and verify that installation requirements are met. The CQA Manager is responsible for assuring that quality assurance testing is completed in accordance with the specifications, and that elements of the RA meet the specifications.

The CQA Manager will maintain daily reports of construction activities at the site. Included in these reports will be a summary of the days activities, a discussion of problems encountered and their solutions, and a discussion on deviations from the approved design. Reports will also include a description of quality assurance testing activities and results. The CQA Manager will be responsible for the oversight of any laboratory testing completed to fulfill requirements of the specifications.

Other Montgomery Watson and Subcontractor Staff

All Montgomery Watson and subcontractor staff are responsible for complying with the construction documents, work plans, procedures, and instructions. The type of subcontractors to be used at the site include the following:

- Earthwork Subcontractor;
- Metal Building Fabricator;
- General Plumbers, Electricians, Utility Workers, Pipe Fitters;
- Concrete Work Subcontractors;
- Equipment Vendors;
- Geotechnical Testing Subcontractor;
- Certified Analytical Laboratory;
- Trenching Subcontractor;
- Well Driller, if required; and,
- Hazardous Waste Transporters and Disposal Facility.

The Construction Superintendent, with assistance from the Site Manager, will provide coordination of the subcontractor activities, including contract bidding and execution, scheduling, site access, equipment and material movement, and documentation.

5.2 BACKGROUND

The PGCS construction project includes the following:

- A 12 to 16 foot deep extraction trench to cut off groundwater flow in the upper aquifer along the downgradient perimeter of the site.

- A treatment system and an associated building and access road.

- A treated effluent conveyance line and wetlands discharge structures.

- Utility services to the treatment building including water, gas, electric, and sanitary sewer.

5.3 CONSTRUCTION ACTIVITY HAZARD ANALYSIS

Montgomery Watson will have at least one person at ACS during the construction to provide project management services and oversee site activities. Montgomery Watson may assist in conducting site health and safety meetings and will conduct health and safety audits. Subcontractors are expected to have an acceptable site safety plan and to abide by it. Specialty subcontractors will perform site tasks, which include:

- Monitoring well and piezometer installation
- Soil excavation and trenching
- Backfilling and soil compaction
- Utilities installation
- Conveyance pipeline installation
  - from the groundwater extraction trench to the treatment system
  - from the treatment system to the wetlands discharge structure
- Welding
- Construction of central control building (due to recent rains in the area, the building will be set on soil pad to avoid contact with groundwater), treatment unit, and access road

Standard operating procedures (SOPs) for safe operation of equipment and execution of work will be the responsibilities of subcontractors. Included herein are some general practices that will be enforced on-site during the PGCS construction activities.

The following hazards are associated with many site activities:

- Chemical hazards
- Noise
- Biological hazards
- Temperature stress
- Working near highways or construction site traffic
- Working at hazardous waste sites
- Ladders
- Fall hazards
- Lifting and materials handling

- Working with and around heavy equipment.

Chemical hazards from site contamination are addressed in Section 2 of the original SSP. Site specific information relating to the tasks included in this amendment is included below and in Table 5-1. Noise and biological hazards are addressed in Section 4 of the original SSP. The SOP for temperature stress is found in Appendix E of the original SSP, and the remaining hazards listed above are addressed in Appendix F of the original SSP.

General hazards specific to each construction activity are listed in Table 5-1, and discussed in the sections below.

5.3.1 Chemical Hazards

Chemicals of concern are found in groundwater for this site. Groundwater is as high as one to two feet below ground surface in certain areas. For this reason, it is assumed that soil in areas of elevated groundwater contamination may also be impacted. The table below provides a listing of the maximum detected value for groundwater contaminant and the well in which it was detected.

Contaminant	Maximum Detected Value (ug/l or ppb)	Monitoring Well Number
VOCs	VOCs	VOCs
Vinyl chloride	16	MW05-01
Chloroethane	3100	MW16-01
Acetone	7700	MW16-01
1,1-dichloroethene	26	MW05-01
1,2-dichloroethene	140	MW16-01
Chloroform	1	TB02-01
1,2-dichloroethane	2	FB01-01
2-butanone	15000	MW16-01
Trichloroethene	1	MW17-01
Benzene	**27000**	**MW03-01**
4-methyl-2-pentanone	14000	MW16-01
Tertrachloroethene	4	MW17-01

Toluene	6	MW05-01
Chlorobenzene	34	MW05-01
Ethylbenzene	770	MW06-01
Xylene	3900	MW06-01
Tetrahydrofuran	3800	MW04S
SVOCs	SVOCs	SVOCs
Phenol	64	MW06-01
bis(2-chloroethyl)ether	160	MW16-01
1,3-dichlorobenzene	2	MW05-01
1,4-dichlorobenzene	7	MW05-01
1,2-dichlorobenzene	51	MW03-01
bis(2-chloroisopropyl)ether	150	MW13-01
4-methylphenol	560	MW16-01
Isophorone	7	MW06-01
2,4-dimethylphenol	58	MW06-01
Naphthalene	2	MW03-01
4-chloro-3-methylphenol	9	MW03-01
2-methylnaphthalene	24	MW17-01
Diethylphthalate	6	MW03-01
Di-n-butylphthalate	2	MW17-01
Di-n-octylphthalate	47	MW06-01
Metals	Metals	Metals
Arsenic	57.1	MW05-01
Manganese	3890	MW04-01
Thallium	3.6	MW04-01
PCBs	1.4	MW04-01

TB = trip blank

FB = field blank

Table 5-2 provides the occupational exposure limits and toxicological information for the chemicals listed above. From the information contained in Table 5-1 and Table 5-2, a list of chemicals of occupational health concern can be selected, based on the chemical's prevalence, relative volatility and likelihood of exposure. Of the compounds detected, four of the SVOCs [4-chloro-3-methylphenol, 1,3-dichlorobenzene, bis(2-

chloroethyl)ether, and bis(2-chloroisopropyl)ether] do not have occupational exposure limits. These compounds are in groundwater and their volatility relatively low. The metals and PCBs pose minimal inhalation hazard to site personnel as they are bound in the water matrix. The metals and PCBs may pose a dermal hazard to site personnel, however. Of the remaining compounds, the only compound detected in groundwater in concentrations greater than its occupational exposure limit is benzene in monitoring well MW03. That is to say, if 100% volatilization were to occur for the other compounds at their maximum detected value, the concentration in air would be below the 8-hour time weighted average allowable exposure limit. Therefore, benzene will be the constituent of occupational concern that will govern the air monitoring program and selection of PPE for the tasks covered under this amendment.

5.3.2. Monitoring Well and Piezometer Installation

Hazards associated with monitoring well and piezometer installation are addressed in the original SSP.

5.3.3. Soil Excavation and Trenching

All trenching operations will be conducted in accordance with 29 CFR 1926 Subpart P. General safety precautions to be used during excavation and trenching activities are summarized below.

- Safety rules for heavy equipment and traffic discussed in Section 4 of the original SSP will be followed.

- All utilities will be cleared as discussed in Section 4 of the original SSP.

- Air monitoring will be performed as described in Table 5-1. A portable sprayer will be used to suppress any dust generated during invasive work. Dust suppression will eliminate the need to conduct real time air sampling for contaminants that adhere to dust, such as metals.

- The buddy system will be employed at all times.

- No trench greater than 3 ft deep will be left unattended or open without adequate barricades, caution tape, and safety signs.

- Personnel and equipment will maintain a minimum 2 foot clearance from the edge of the excavation.

- Suitable storage for all tools, materials, and supplies will be provided by the contractor (or subcontractor).

- Work areas will be kept free of materials, obstructions, and substances that could cause a surface to become slick or otherwise hazardous.

- Tools and equipment will be used in accordance with the manufacturers recommended methods. The operators shall be responsible for establishing safe equipment use procedures and communicating these to site workers.

- Unattended excavations must be properly covered or otherwise secured when work is not active.

- Soil shall be backfilled as soon as possible.

Montgomery Watson employees will not enter any trenches greater than 4 feet in depth during this project. Should this change, Montgomery Watson personnel will follow the safe excavation entry procedures provided by the excavation contractor. The excavation contractor is required to have safe excavation entry procedures on site covering all entry tasks and hazards.

5.3.4. Backfilling and Soil Compaction

Safety precautions for backfilling and soil compaction are also to be covered in the contractor's standard safe operating procedures for excavation and trenching.

5.3.5. Electrical Line Installation

Electrical hazards are summarized in Section 4 of the original SSP. Controlling electrical hazards and ground-fault protection on construction sites are discussed in more detail in Attachment A of this amendment. Electrical work will only be conducted by a trained, experienced, and licensed electrical subcontractor, and will conform with 29 CFR 1910.147.

5.3.6. Piping Installation

The specific hazards associated with piping installation include possible excavation entry and connecting piping. Employees entering any trenches/excavations greater than 4 feet in depth during this project will follow the contractor's safe excavation entry procedures. The subcontractor installing the piping will provide workers with material safety data sheets (MSDS) explaining the potential hazards associated with the materials used, and will develop safe handling procedures including the use of appropriate PPE.

5.3.7. Welding

The specific hazards associated with welding include fire and explosion, exposure to toxic gases and fumes, and exposure to dangerously intense light. Should welding be necessary, all appropriate hot work permits will be obtained in advance and all unnecessary personnel shall be cleared from the welding site. Welders shall wear appropriate PPE and conduct appropriate air monitoring. The SSO will be responsible for fire control measures as outlined in Appendix F of the original SSP. Hazards associated with welding are discussed in more detail in Attachment A of this amendment.

5.3.7. Construction of the Central Control Building, Treatment Unit, and Access Road

Specific hazards associated with construction of the central control building, treatment unit, and access road include industrial truck and crane operation, and the use of portable hand and power tools. Safety precautions for these activities are found in Section 4 of the original SSP and Attachment A of this amendment.

5.4.1 TASK-SPECIFIC LEVELS OF PROTECTION

The initial level of protection and air monitoring required for each site activity is listed in Table 5-1. The air monitoring equipment and action levels for upgrading personal protective equipment (PPE) are discussed in Section 5.0 of the original SSP.

5.4.2 REQUIRED PPE

The requirements for PPE to be utilized are outlined in Section 5 of the original SSP. For work being performed in Level D in accordance with the SSP, and where the site safety officer determines no overhead hazard is present, hard hats will be considered optional for the tasks listed below:

- Construction of the treatment building footings, foundation, and floor slab.
- Construction of the access roadway.
- General site inspection outside of the ACS facility and outside of 50 ft of construction activities with overhead hazards.

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EMERGENCY INFORMATION

For Construction Activities

	Address	Telephone or Mobil*	Contact Person
Ambulance		911 or *999	
Hospital E/R	Munster Community Hosp. 901 McArthur Boulevard Munster, Indiana	(219) 836-1600	
Poison Control		(800) 942-5969	
Police		911 or *999	
Fire		911 or *999	
Client		(219)	
EPA/other agency	U.S. EPA	(312) 353-2318	
Utilities	Indiana Dig	(800) 382-5544	
Chemtrec		(800) 424-9300	

Spill Response
*Note: when using a mobile telephone, *999 only works on state highways, otherwise dial "0" for operator assistance to direct you to the appropriate emergency service.

Emergency Contacts	Name	Business Phone	Home Phone
Project Manager	Peter Vagt	(708) 691-5020	(708) 665-4629
Site Safety Officer	Lee Orosz	(708) 691-5120	(219) 462-2308
H&S Coordinator	Lee Orosz	(708) 691-5120	(219) 462-2308
H&S Manager	Joe Willich	(708) 691-5087	(219) 464-0575
Site Manager (alt)	Ben McGeachy	(708) 691-5103	(219) 836-0787
Construction Mgr.	Todd Lewis	(708) 961-5061	(708) 424-0891

TABLE 5-1
CONSTRUCTION ACTIVITY HAZARTD ANALYSIS

TASK	GENERAL HAZARDS	INITIAL LEVEL OF PPE	AIR MONITORING
Soil Excavation and trenching	• Exposure to site contaminants • Noise • Biological hazards • Temperature extremes • Construction site traffic • Slip/trip/fall • Operation of heavy equipment • Electrocution	Level D	VOCs: PID (10.2 or 10.6 eV probe) initially and every 60 minutes thereafter. If >1 ppm above background sustained for 15 minutes: Pull a Benzene Drager tube (order number 8101841). If any posative detection upgrade PPE to Level C. Oxygen/LEL: when entering excavation >4 feet deep.
Backfilling and soil compaction	• Noise • Biological hazards • Temperature extremes • Construction site traffic • Slip/trip/fall • Operation of heavy equipment	Level D	• Not required for clean soils • Same as for VOCs above when handling impacted soils.
Electrical line installation to building (note that this activity will be conducted through unimpacted soil)	• Noise • Biological hazards • Temperature extremes • Construction site traffic • Slip/trip/fall • Heavy lifting • Electrocution	Level D	None required
Piping and Electrical Installation	• Exposure to site contaminants • Noise • Biological hazards • Temperature extremes • Construction site traffic • Slip/trip/fall • Operation of heavy equipment • Electrocution • Exposure to doping and bonding compounds	Level D when working northwest of the extraction trench. Level C until benzene exposure is characterized when working southeast of the extraction trench.	• None required when working northwest of the extraction trench. • Same monitoring described for soil excavation and trenching above for work southeast of the extraction trench. • Contractor's industrial hygienist to determine if monitoring is required for doping and bonding compounds.
Welding	• Exposure to welding materials • Noise • Biological hazards • Temperature extremes • Construction site traffic • Slip/trip/fall • Fire and explosion	Level D	• The subcontractor's industrial hygienist to determine if monitoring is required for welding operations.
Construction of central control building, treatment unit and access road.	• Noise • Temperature extremes • Construction site traffic • Use of ladders • Slip/trip/fall • Heavy lifting • Operation of heavy equipment • Hand and portable power tools.	Level D	None required

TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
BENZENE	1 ppm	0.1 ppm	10 ppm	5 ppm	3,000 ppm	9.24	INH, CON, ABS, ING	Irritant to eyes, noes and respiratory system; giddiness; headache; nausea; staggered gait; fatigue; anorexia; lassitude; dermatitis; bone marrow depression; CARCINOGEN.
BIS(2-CHLOROETHYL)ETHER	There are no occupational exposure values for this material					NA	CON	Irritating to skin, eyes and mucous membranes.
BIS(2-CHLOROISOPROPYL)-ETHER	There are no occupational exposure values for this material					NA	NA	NA
BIS(2-ETHYLHEXYL) PHTHALATE	5 mg/m^3	5 mg/m^3	NA	NA	5,000 mg/m^3	NA	INH, ING, CON	Irritant to eyes, mucous membranes.
CHLOROBENZENE	75 ppm	NA	10 ppm	NA	2,400 ppm	9.07	INH, ING CON	Irritant to the skin, eyes and nose; drowsiness; incoherence.
CHLOROFORM	2 ppm	Carcinogen (lowest possible)	10 ppm	NA	500 ppm	11.42	INH, ING CON, ABS	Irritant to eyes and skin; dizziness, mental dullness, nausea, confusion; headache, fatigue; anesthesia; enlarged liver; CARCINOGEN.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
p-CRESOL (2-,3- and 4-METHYLPHENOL)	5 ppm	2.3 ppm	5 ppm	NA	250 ppm	8.93, 8.98, 8.97	INH, ING, CON, ABS	Irritant to eyes, skin and mucous membranes; CNS effects; confusion; depression; respiratory failure, dyspnea, irregular rapid respiration; weak pulse; eye and skin burns, dermatitis; lung, liver, kidney pancrease damage.
DI-n-BUTYLPHTHALATE	5 mg/m^3	5 mg/m^3	5 mg/m^3	NA	9300 mg/m^3	NA	INH, ING, CON	Irritant to upper respiratory tract, and stomach.
DIETHYLPHTHALATE	5 mg/m^3	5 mg/m^3	5 mg/m^3	NA	NA	NA	INH, ING	Toxic by ingestion and inhalation; strong irritant to eyes and mucous membranes; narcotic.
ETHYLBENZENE	100 ppm	100 ppm	100 ppm	125 ppm	2,000 ppm	8.76	INH, ING CON	Irritant to eyes, mucus membranes, headache, dermatitis, narcosis, coma.
ETHYL CHLORIDE (CHLOROETHANE)	1,000 ppm	Handle with care	100 ppm	NA	3,800 ppm (LEL)	10.97	INH, ING, CON, ABS	Incoherence, inebriation, abdominal cramps, cardiac arrhythmia, cardiac arrest, liver and kideny damage.
ISOPHORONE	25 ppm	4 ppm	5 ppm ceiling	NA	200 ppm	9.07	INH, ING, CON	Irritant to eyes, nose, throat, headache, nausea, dizziness, fatigue, malaise, narcosis, dermatitis.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
MANGANESE	5 mg/m^3 (ceiling limit)	1 mg/m^3	5 mg/m^3	3 mg/m^3	NA	NA	INH, ING	Parkinson's asthemnia, insomnia, mental confusion; metal fume fever; dry throat, cough, tight chest, dyspnea, rales, flu-like fever; low-back pain; vomiting; malaise; fatigue.
METHYL ETHYL KETONE	200 ppm	200 ppm	200 ppm	300 ppm	3,000 ppm	9.54	INH, CON ING	Irritant to eyes and nose; headache; dizziness; and vomiting.
METHYL ISOBUTYL KETONE	50 ppm	100 ppm	50 ppm	75 ppm	500 ppm	9.3	INH, ING, CON	Irritant to eyes, skin and mucous membranes; headache, narcosis, coma; dermatitis.
2-METHYLNAPHTHALENE	No occupational exposure values exist					NA	NA	Moderate fire risk.
NAPHTHALENE	10 ppm	10 ppm	10 ppm	15 ppm	500 ppm	8.12	INH, ING, CON, ABS	Eye irritant; headache; confusion; excitement, malaise, nausea, vomiting, abdominal pain, irritated bladder; profuse sweating; jaundice; renal shutdown; dermatitis.
PCB	0.5 mg/m^3	0.001 mg/m^3	0.5 mg/m^3	NA	5 mg/m^3	NA	INH, ING, CON, ABS	Irritant to eyes, skin; acne-form dermatitis; CARCINOGEN.

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TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
PHENOL	5 ppm	5 ppm	5 ppm	15.6 ppm Ceiling	250 ppm	8.50	INH, ING, CON, ABS	Irritant to eyes, nose, throat; anorexia, low-weight; weakness, muscle ache and pain; dark urine; cyanosis; liver and kidney damage; skin burns; dermatitis; ochronosis; tremor, convulsion, twitching.
TETRACHLOROETHYENE	25 ppm	25 ppm	25 ppm	100 ppm	500 ppm	9.32	INH, ING, CON	Irritant to eyes, nose and throat; nausea; flush face, and neck; vertigo, dizziness, incoherence; headache, somnolescence; skin erythema; liver damage; CARCINOGEN.
TETRAHYDROFURAN	200 ppm	200 ppm	200 ppm	250 ppm	2,000 ppm (LEL)	9.45	INH, ING, CON	Iritant to eyes, upper respiratory system; nausea, dizziness, headache and CNS depression.
THALLIUM	0.1 mg/m^3	0.1 mg/m^3	0.1 mg/m^3	NA	20 mg/m^3	NA	INH, ING, CON, ABS	Nausea, diarrhea, abdominal pain, vomiting; ptosis, strabismus; peripheral neuritis, tremor; retrosternal tightness, chest pain, pulmonary edema; seizure, chorea, psychosis; liver and kidney damage; alopecia; paresthesia in the legs.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
TOLUENE	100 ppm	100 ppm	50 ppm	NA	2,000 ppm	8.82	INH, ING CON, ABS	Fatigue, weakness, confusion, euphoria, dizziness, headache, dilated pupils, lactimation, nervousness, muscle fatigue, insomnia, paresthesia and dermatitis.
TRICHLOROETHYLENE	25 ppm	25 ppm	50 ppm	100 ppm	1,000 ppm	9.45	INH, ING, CON	Headache, vertigo; visual disturbance, tremors, somnolescence, nausea, vomiting; irritation to eyes; dermatitis; cardiac arrhythmia; CARCINOGEN.
VINYL CHLORIDE (CHLOROETHENE)	1 ppm	Carcinogen	5 ppm	NA	Carcinogen	9.99	INH, CON	Weekness; abdominal pain, gastro-intestinal bleeding; enlarged liver; pallor or cyanosis of extremities; CARCINOGEN.
XYLENE	100 ppm	100 ppm	100 ppm	150 ppm	1,000 ppm	8.44-8.56	INH, ING, CON, ABS	Dizziness; excitement; drowsiness; incoherence; staggering gait; irritant to eyes, nose and throat; corneal vacuolization; anorexia; nausea; vomiting; abdominal pain; dermatitis.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

TABLE 5-2

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
4-CHLORO-3-METHYLPHENOL	No occupational exposure values exist					NA	NA	Irritant to skin.
1,1-DICHLOROETHYLENE (VINYLIDENE CHLORIDE)	Carcinogen	Carcinogen	5 ppm	20 ppm	NA	10.0	INH, CON, ING, ABS	Central nervous system depression; irritant to eyes, skin and throat; nausea, dyspnea; inebriation; unconsciousness in high acute doses; liver and kidney damage; CARCINOGEN
1,2-DICHLOROBENZENE	50 ppm Ceiling	50 ppm Ceiling	25 ppm	50 ppm	200 ppm	9.06	INH, ING, CON, ABS	Irritant to eyes, nose; liver and kidney damage; skin blisters.
1,2-DICHLOROETHANE	1 ppm	1 ppm Ca	10 ppm	2 ppm	400 ppm	11.05	INH, CON ING, ABS	Central nervous system depression; nausea, vomiting; dermatitis; eye irritant; corneal opacity; CARCINOGEN
1,3-DICHLOROBENZENE (META)	No occupational exposure values exist					NA	NA	NA Used as a fumigant and insecticide.
1,2-DICHLOROETHYLENE	200 ppm	200 ppm	200 ppm	NA	4,000 ppm	9.65	INH, ING, CON	Irritant to eyes, respiratory system; central nervous system depression.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

TABLE 5-2 (Continued)

OCCUPATIONAL HEALTH EXPOSURE AND TOXICOLOGICAL PROPERTIES FOR CONTAMINANTS OF OCCUPATIONAL HEALTH CONCERN

Contaminant	OSHA PEL	NIOSH REL	ACGIH TLV	ACGIH/OSHA STEL	OSHA/ NIOSH IDLH	IP eV	Route of Exposure	Symptoms of Exposure
1,4-DICHLOROBENZENE	75 ppm	Carcinogen (Lowest feasible)	75 ppm	110 ppm	1,000 ppm	8.98	INH, ING, CON	Headache; eye irritation, periorbital swelling, profuse rhinitis; anorexia, nausea, vomiting; low-weight, jaundice; CARCINPGEN.
2,4-DIMETHYLPHENOL	5 ppm	2.3 ppm	5 ppm	NA	250 ppm	8.93, 8.97, 8.98	INH, CON ING, ABS	Central nervous system effects; confusion, depression, respiratory failure; dyspnea, irregular rapid respiration, week pulse; skin and eye burns; dermatitis; lung, liver and kidney damage.
ACETONE	750 ppm	250 ppm	750 ppm	1,000 ppm	20,000 ppm	9.69	INH, ING, CON	Irritant to eyes, nose and throat; headache, dizziness; dermatitis.
ARSENIC	0.01 mg/m^3	0.002 mg/m^3	0.01 mg/m^3	NA	100 mg/m^3	NA	INH, ING, CON, ABS	Ulceration of nasal septum, dermatitis, gastro-intestinal disturbances, peripheral neuropathy, respiratory irritant, hyperpigmentation of the skin, CARCINOGEN.

INH = Inhalation ING = Ingestion ABS = Skin Absorption CON = Skin or mucous membrane contact
NA = Not applicable or available Ca = NIOSH considered carcinogen CNS = Central Nervous System

ATTACHMENT A

GENERAL HEALTH AND SAFETY PROCEDURES

OPERATING RULES FOR INDUSTRIAL TRUCKS

The following are established as Operating Rules - Industrial Trucks. The term "Industrial Trucks" includes mobile power driven trucks or tractors used for hauling, pushing, lifting or tiering materials. Compliance with these Rules is required of all employees. Violation of these Rules will result in disciplinary action.

1. Only drivers authorized by the employer and trained in the safe operations of industrial trucks or industrial tow tractors shall be permitted to operate such vehicles. Methods shall be devised to train operators in safe operation of powered industrial trucks.

   Drivers shall not operate trucks other than those for which they are authorized. Trainees may be authorized to operate trucks provided they are under competent supervision.

2. Drivers shall check the vehicle at least once per shift, and if it is found to be unsafe, the matter shall be reported immediately to a foreman or mechanic, and the vehicle shall not be put in service again until it has been made safe. Attention shall be given to the proper functioning of tires, horn lights, battery, controller, brakes, steering mechanism, and the lift system of fork lifts (fork, chains, cable, and limit switches)

3. Vehicle shall not exceed the authorized or safe speed, always maintaining a safe distance from other vehicles, keeping the truck under positive control at all times and all established traffic regulations shall be observed. For trucks traveling in the same direction, a safe distance may be considered to be approximately 3 truck lengths or preferably a time lapse- 3 seconds- passing the same point.

4. No riders shall be permitted on vehicles unless provided with adequate riding facilities.

5. Stunt driving and horseplay are prohibited.

6. Loaded vehicles shall not be moved until the load is safe and secure.

7. When leaving a vehicle unattended, the power shall be shut off, brakes set, the mast brought to the "vertical position" , and forks left in the down position. When left on an incline, the wheels shall be blocked.

   - NOTE: A powered industrial truck is unattended when the operator is 25 feet or more away from the vehicle which remains in his view, or whenever the operator leaves the vehicle and it is not in his view.

   - When the operator of an industrial truck is dismounted and within 25 feet of the truck still in his view, the load engaging means shall be fully lowered, controls neutralized, and the brakes set to prevent movement.

8. Trucks shall not be driven up to anyone standing in front of a bench or other fixed object of such size that the person could be caught between the truck and object.

9. Operators shall look in the direction of travel and shall not move a vehicle until certain that all person are in the clear.

10. Vehicles shall not be run onto any elevator unless specifically authorized to do so. Before entering an elevator, driver shall make sure that the capacity of the elevator is not exceeded. Once on an elevator, they shall shut off the power and set the brakes.

11. Vehicles shall not be operated on floors, sidewalk doors, or platforms that will not safely support the loaded vehicle.

    - Any damage to industrial trucks and/ or structures shall be reported immediately to the foreman.

The following additional rules shall apply to fork lift trucks:

12. Employees shall not ride on the forks of lift trucks.

13. The forks shall always be carried as low as possible, consistent with safe operation.

14. Extreme care shall be used when tilting loads.

15. Vehicles shall not be driven in and out of highway trucks and trailers at unloading docks until such trucks are securely blocked and brakes set.

16. Employees shall not place any part of their body outside the running lines of the industrial truck or between mast uprights or other parts of the truck where shear or crushing hazards exist.

17. Employees shall not be allowed to stand, pass, or work under the elevated portion of any industrial truck, loaded or empty, unless it is effectively blocked to prevent it from falling.

18. Railroad tracks shall be crossed diagonally wherever possible. Parking closer than 8 1/2 feet from centerline of railroad track is prohibited.

19. The width of one tire on the powered industrial truck shall be the minimum distance maintained from the edge by the truck while it is on any elevated dock, platform or freight car.

20. When powered industrial trucks are used to open and close freight car doors, the following provisions shall be complied with:

    - (A) A device specifically designed for opening or closing freight car doors shall be attached to the truck.

    - (B) The force applied by the device to the freight car door shall be applied parallel to the direction of travel of the freight car door.

    - (C) The entire door opening operation shall be in full view of the operator.

    - (D) The truck operator and other dock employees shall be clear of the area where the door might fall while being opened.

21. Prior to driving onto trucks, trailers and railroad cars, their flooring shall be checked for breaks and other structural weaknesses.

22. Other trucks traveling in the same direction shall not be passed at intersections, blind spots, or dangerous locations.

23. The driver shall slow down and sound the horn at cross aisles and other locations where vision is obstructed. If the load being carried obstructs forward view, the driver shall be required to travel with the load trailing.

24. Grades shall be ascended or descended slowly.

- (A) When ascending or descending grades in excess of 10 percent, loaded trucks shall be driven with load upgrade.

- (B) On all grades the load and load engaging means shall be tilted back if applicable and raised only as far as necessary to clear the road surface.

- (C) Motorized hand and hand/rider trucks shall be operated on all grades with the load-engaging means downgrade.

25. Trucks shall not be loaded in excess of their rated capacity.

26. Motorized hand trucks shall enter elevators or other confined areas with the load and forward.

27. No truck shall operate with a leak in the fuel system.

28. Extreme care shall be taken when tilting loads. Tilting forward with the load engaging means elevated shall be prohibited except when picking up a load. Elevated loads shall not be tilted forward except when the load is being deposited onto a storage rack or equivalent. When stacking or tiering, backward tilt shall be limited to that necessary to stabilize the load.

29. The load engaging device shall be placed in such a manner that the load will be securely held or supported.

30. Special precautions shall be taken in the securing and handling of loads by trucks equipped with attachments, and during the operation of these trucks after the loads have been removed.

SOURCE: CCR General Industry Safety Order Section 3669

OPERATING RULES FOR CRANES

The following is based on a set of operating rules for crane operators, from the Crane Manufacturers Association of America, Inc.

1. Crane controls should be operated smoothly and gradually to avoid abrupt, jerky movements of the load. Slack must be taken from the sling and hoisting ropes before the load is lifted.

2. The crane should be centered over the load before starting the hoist to avoid swinging the load as the lift is started. Loads should not be swung by the crane's reach areas not under the crane.

3. Crane hoisting ropes should be kept vertical. Cranes must not be used for side pulls.

4. The block should never be lowered below the point where less than two full wraps of rope remain on the hoisting drum. Should all the rope be unwound from the drum, it should be rewound in the correct direction and seated properly in the drum groove, otherwise the rope will be damaged and the hoist limit switch will not operate to stop the hoist in the high position.

5. Everyone in the immediate area should be clear of the load and aware that a load is being moved. A warning device should be sounded (if provided) when raising, lowering, or moving loads wherever people are working to make them aware that a load is being moved. Additional warning devices can be used in high-traffic areas.

6. Lifts should not be attempted beyond the rated load capacity of the crane, sling chains, rope slings, etc.

7. If limit switches are out of order or if ropes show defects or wear, the crane should not be operated.

8. Before moving a load, load slings, load chains, or other load lifting devices must be fully seated in the saddle of the hook.

9. When a duplex hook (double saddle hook) is used, a double sling or choker should be used to assure that the load is equally divided over both saddles of the hook.

10. On all capacity or near-capacity loads, the hoist brakes should be tested by returning the master switch or pushbutton to the OFF position after raising the load a few inches off the floor. If the hoist brakes do not hold, the load should be set on the floor and the crane not operated. The defect should be reported immediately to the supervisor.

11. The load should be checked to be certain that it is lifted high enough to clear all obstructions and personnel when moving the bridge or trolley.

12. At no time should a load be held suspended from the crane unless the operator is at the master switches or pushbutton with the power on, and under this condition, the load should be kept as close as possible to the floor to minimize the possibility of an injury if the load should drop.

13. When a hitcher is used, it is the joint responsibility of the crane operator and the hitcher to see that hitches are secure and that all loose material has been removed from the load before starting a lift.

14. Sling hooks hanging loose should not be used to lift loads. (If sling hooks are not needed, they should be properly stored.)

15. All slings or ropes should be removed from the crane hooks when not in use. (Dangling slings or hooks hung in sling rings can inadvertently snag other objects when moving the crane.)

16. Crane operators should not use limit switches to stop the hoist under normal operating conditions. (These are emergency devices and are not to be used as operating controls.)

17. Limit switches should not be blocked, adjusted, or disconnected in order to go higher than the switch will allow.

18. Upper limit switches (and lower limit switches, when provided) should be tested in stopping the hoist at the beginning of each shift, or as frequently as may be directed.

19. Loads must never be moved over anyone, especially loads carried by magnets or vacuum devices. Loads, or parts of loads, held magnetically may drop. Failure of power to magnets or vacuum devices will result in dropping the load unless a backup power supply is furnished.

20. Loads must never be carried over people.

21. If the electric power is disrupted, the controllers must be placed in the OFF position and kept there until power is again available.

22. Before closing main or emergency switches, all controllers must be in the OFF position before reversing - except to avoid accidents. (A slight pause is necessary to give the braking mechanism time to operate.)

23. If plugging protection is not provided, the controllers must always be stopped momentarily in the OFF position before reversing - except to avoid accidents. (A slight pause is necessary to give the braking mechanism time to operate.)

24. Before leaving a crane, the operator should perform the following:

    (a) Raise all hooks to an intermediate position.
    (b) Spot the crane at an approved designated location.
    (c) Place all controls in the OFF position.
    (d) Open the main switch to the OFF position.
    (e) Make visual check before leaving the crane.

    Note: On yard cranes (cranes on outside runways), operators should set the brake and anchor securely so the crane will not be moved by the wind.

25. When two or more cranes are used in making one lift, it is very important that the crane operators take signals from only one designated person.

26. An attempt should never be made to close a switch that has an OUT OF ORDER or DO NOT OPERATE card on it. It is necessary to make a careful check to determine that no one else is working on the crane, before removing the card.

27. In case of emergency or during inspection, repairing, cleaning or lubricating, a warning sign or signal should be displayed and the main switch should be locked in the OFF position. This procedure should be followed whether the work is being done by the crane operator or by others. On cab-operated cranes when others are doing the work, the crane operator should remain in the crane cab unless otherwise instructed by the supervisor.

28. A crane should never move or bump another crane that has a warning sign signal displayed. Contacts with runway stops or other cranes shall be made with extreme caution. The operator must take particular care for the safety of persons on or below the crane, and only after making certain that any persons on the other cranes are aware of what is being done.

29. Fuse sizes should not be changed. Do not attempt to repair electrical apparatus or make other major repairs on the crane unless specific authorization has been received.

30. Electrical limit switches or warning devices should never be bypassed.

31. Load limit or overload devices must not be used to measure loads being lifted. This is an emergency device and is not to be used as a production operating control.

GENERAL MAINTENANCE SAFETY RULES

These rules are taken from *ANSI Standard Safety Code for Overhead and Gantry Cranes*, B30.2.0:

1. To be repaired, a crane must be moved to a location where there will be minimum interference with other cranes and operations in the area.

2. All controllers should be in the OFF position.

3. The main power source should be disconnected, de-energized and locked, tagged, or flagged in the de-energized position.

4. WARNING or OUT OF ORDER signs should be placed on the crane, on the floor beneath, or on the hook where they are visible from the floor.

5. If other cranes are in operation on the same runway, rail stops or other suitable devices shall be provided to protect the idle crane.

6. Where rail stops or other devices are not available or practical, a person should be located where he can warn the operator by reaching the limit of safe distance from the idle crane.

7. Where there are adjacent craneways and the repair area is not protected by wire mesh or other suitable protection, or if any hazard from adjacent operations exists, the adjacent runway must also be restricted. A signaler shall be provided when cranes on the adjacent runway pass the work area. Cranes shall come to a full stop and may proceed through the area on being given a signal from the designated person.

8. Trained personnel shall be provided to work on energized equipment when adjustments and tests are required.

9. After all repairs have been completed, guards shall be reinstalled, safety devices reactivated, and maintenance equipment removed before restoring crane to service.

SOURCE: National Safety Council, 1980. Accident Prevention Manual for Industrial Operations, Engineering and Technology, 8th Edition.

HAND TOOLS

Hand tools are non-powered. They include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance.

Some examples:

- Using a chisel as a screwdriver may cause the tip of the chisel to break and fly, hitting the user or other employees.
- If a wooden handle on a tool such as a hammer or an ax is loose, splintered, or cracked, the head of the tool may fly off and strike the user or another worker.
- A wrench must not be used if its jaws are sprung because it might slip.
- Impact tools such as chisels, wedges, or drift pins are unsafe if they have mushroomed heads. The heads might shatter on impact, sending sharp fragments flying.

The employer is responsible for the safe condition of tools and equipment used by employees, but the employees have the responsibility for using and maintaining tools properly.

Employers should caution employees that saw blades, knives, or other tools be directed away from aisle areas and other employees working in close proximity. Knives and scissors must be sharp. Dull tools can be more hazardous than sharp ones.

When employees are working with hand knives, boning knives, draw knives, and scissors, they should use personal protective equipment such as wire mesh gloves, wrist guards, arm guards, and aprons or belly guards.

Safety requires that floors be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

Around flammable substances, sparks produced by iron or steel hand tools can be a dangerous ignition source. Where this hazard exists, spark-resistant tools made from brass, plastic, aluminum, or wood will provide safety.

POWER TOOL PRECAUTIONS

Power tools can be hazardous when improperly used. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

Employees should be trained in the use of all tools—not only power tools. They should understand potential hazards and safety precautions to prevent those hazards from occurring.

The following general precautions should be observed by power tool users:

- Never carry a tool by the cord or hose
- Never yank the cord or the hose to disconnect from the receptacle
- Keep cords and hoses away from heat, oil, and sharp edges
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits, and clutters
- Keep all observers at a safe distance from the work area
- Secure work with clamps or a vise, freeing both hands to operate the tool
- Avoid accidental starting.. The worker should not hold a finger on the switch button while carrying a plugged-in tool
- Maintain tools with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories
- Be sure to keep good footing and maintain good balance
- Wear proper apparel. Loose clothing, ties, or jewelry can become caught in moving parts
- Remove all portable electric tools and tag with "Do Not Use"

GUARDS

Hazardous moving parts of a power tool need to be safeguarded. For example, belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other

reciprocating, rotating, or moving parts of equipment must be guarded if such parts are exposed to contact by employees.

Guards, as necessary, should be provided to protect the operator and others from

- point of operation,
- in-running nip points,
- rotating parts, and
- flying chips and sparks.

Safety guards must never be removed when the tool is being used. For example, portable circular saws must be equipped with guards. An upper guard must cover the entire blade of the saw. A retractable lower guard must cover the teeth of the saw, except when it makes contact with the work material. The lower guard must automatically return to the covering position when the tool is withdrawn from the work.

SAFETY SWITCHES

The following hand-held powered tools must be equipped with a momentary contact "on-off" control switch: drills, tappers, fastener drivers, horizontal, vertical and angle grinders with wheels larger than two inches in diameter, disc sanders, belt sanders, reciprocating saws, saber saws, and other similar operations. These tools may also be equipped with a lock-on control provided that turnoff can be accomplished by a single motion of the same finger or fingers that turn it on.

The following hand-held powered tools may be equipped with only a positive "on-off" control switch: platen sanders, grinders with wheels two inches or less in diameter, routers, planers, laminate trimmers, nibblers, shears, scroll saws and jigsaws with blade shanks one-fourth inch wide or less.

Other hand-held powered tools such as circular saws, chain saws, and percussion tools without positive accessory holding means must be equipped with a constant pressure switch that will shut off the power when the pressure is released.

ELECTRIC TOOLS

Employees using electric tools must be aware of several dangers; the most serious is the possibility of electrocution.

Among the chief hazards of electric-powered tools are burns and slight shocks which can lead to injuries or even heart failure. Under certain conditions, even a small amount of current can result in fibrillation of the heart and eventual death. A shock also can cause the user to fall off a ladder or other elevated work surface.

To protect the use from shock, tools must either have a three-wire cord with ground and be grounded, be double insulated, or be powered by a low-voltage isolation transformer. Three-wire cords contain two current-carrying conductors and a grounding conductor. One end of the grounding conductor connects to the tool's metal housing. The other end is grounded through a prong on the plug. Anytime an adapter is used to accommodate a two-hole receptacle, the adapter wire must b attached to a known ground. The third prong should never be removed from the plug.

Double insulation is more convenient. The user and the tools are protected in two ways: by normal insulation on the wires inside and by a housing that cannot conduct electricity to the operator in the event of a malfunction.

The following general practices should be followed when using electric tools:

- Electric tools should be operated within their design limitations.
- Gloves and safe footwear are recommended during use of electric tools.
- Tools not in use should be stored in a dry place.
- Electric tools should not be used in damp or wet locations.
- Work areas should be well lighted.

POWER ABRASIVE WHEEL TOOLS

Powered abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments.

Before an abrasive wheel is mounted, it should be inspected closely and sound or ring-tested to be sure that it is free from cracks or defects. To test, wheels should be tapped gently with light non-metallic implement. If they sound cracked or dead, they could fly apart in operation and so must not be used. A sound or undamaged wheel will give a clear metallic tone or "ring."

To prevent the wheel from cracking, the user should be sure it fits freely on the spindle. The spindle nut must be tightened enough to hold the wheel in place, but not tight enough to distort the flange. Follow the manufacturer's recommendations. Care must be taken to assure that the spindle wheel will not exceed the abrasive wheel specifications.

Due to the possibility of a wheel disintegrating (exploding) during start-up, the employee should never stand directly in front of the wheel as it accelerates to full operating speed.

Portable grinding tools need to be equipped with safety guards to protect workers, not only from the moving wheel surface but also from flying fragments in case of breakage.

In addition, the following rules should be followed when using a powered grinder:

- Always use eye protection
- Turn off the power when not use
- Never clamp a hand-held grinder in a vise

PNEUMATIC TOOLS

Pneumatic tools are powered by compressed air; they include chippers, drills, hammers, and sanders.

There are several dangers encountered in the use of pneumatic tools. The main one is the danger of getting wet by one of the tool's attachments or some kind of fastener the worker is using with the tool.

Pneumatic tools that shoot nails, rivets, or staples, and operate at more than 100 pounds per square inch, must be equipped with a special device to keep fasteners from being ejected unless the muzzle is pressed against the work surface.

Eye protection is required and face protection is recommended for employees working with pneumatic tools.

Noise is another hazard. Working with noisy tools such as jackhammers requires proper, effective use of ear protection. (For more information on noise, see OSHA publication 3074, Hearing Conservation.)

When using pneumatic tools, employees must check to see that they are fastened securely to me hose by a positive means to prevent them from becoming disconnected. A short wire or positive locking device attaching the air hose to the tool will serve as an added safeguard.

Airless spray guns which atomize paints and fluids at high pressures (1,000 pounds or more per square inch) must be quipped with automatic or visual manual safety devices which will prevent pulling the trigger until the safety device is manually released.

If an air hose is more than one-half inch in diameter, a safety excess flow valve must be installed at the source of the air supply to shut off the air automatically in case the hose breaks.

In general, the same precautions should be taken with an air hose that are recommended for electric cords, because the hose is subject to the same kind of damage or accidental striking and presents tripping hazards.

A safety clip or retainer must be installed to prevent attachments, such as chisels on a chipping hammer, from being unintentionally shot from the barrel.

Screens must be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or aid drills.

Compressed air guns should never be pointed toward anyone. The user should never "dead-end" it against him or herself or anyone else.

Heavy jackhammers can cause fatigue and strains; heavy rubber grips reduce these effects by providing a secure handhold.

Workers operating a jackhammer must wear safety glasses and safety shoes, which protect against injury if the hammer slips of falls. A face shield should also be sued.

LIQUID-FUEL TOOLS

A third type of tool is fuel-powered, usually by gasoline. The most serious hazard with fuel-powered tools comes from fuel vapors that can burn or explode and give off dangerous exhaust fumes.

The worker must be careful handling, transporting, and storing the gas or fuel in approved flammable liquid containers, according to proper procedures for flammable liquids.

Before the tank for a fuel-powered tool is refilled the user must shut the engine down and allow it to cool to prevent accidental igniting of hazardous vapors.

If a fuel-powered tool is used inside a closed area, effective ventilation and/or personal protective equipment is necessary to avoid breathing carbon monoxide. Fire extinguishers must be available in the area.

POWDER-ACTUATED TOOLS

Powder-actuated tools operate like a loaded gun and should be treated with the same respect and precautions. In fact, they are so dangerous that they must be operated only by specially trained employees.

These are safety precautions to remember:

- These tools should not be used in an explosive or flammable atmosphere.
- Before using the tool, the worker should inspect it to determine that it is clean, that all moving parts operate freely, and that the barrel is free from obstructions.
- The tool should never be pointed at anybody.
- The tool should not be loaded unless it is to be used immediately. A loaded tool should not be left unattended, especially where it would be available to unauthorized persons.
- Hands should be kept clear of the barrel end. To prevent the tool from firing accidentally, two separate motions are required for firing: one to bring the tool into position and another to pull the trigger. The tools must not be able to operate until they are pressed against the work surface with a force of at least five pounds greater than the total weight of the tool.

If a powder-actuated tool misfires, the employee should wait at least 30 seconds, then try firing it again. If it still will not fire, the user should wait another 30 seconds so that the faulty cartridge is less likely to explode, then carefully remove the load. The bad cartridge should be put in water.

Suitable eye and face protection are essential when using a powder-actuated tool.

The muzzle end of the tool must have a protective shield or guard centered perpendicularly on the barrel to confine any flying fragments or particles which might otherwise create a hazard when the tool is fired. The tool must be designed so that it will not fire unless it has this kind of safety device.

All powder-activated tools must be designed for varying powder charges to that the user can select a powder level necessary to do the work without excessive force.

If the tool develops a defect during use it should be tagged and taken out of service immediately until it is properly repaired.

FASTENERS

When using powder-actuated tools to apply fasteners there are some precautions to consider. Fasteners must not be fired into material which would let them pass through to the other side. The fastener must not be driven into materials like brick or concrete any closer than three inches to an edge or corner. In steel, the fastener must not come closer than a half inch from a corner or edge. Fasteners must not be driven into very hard or brittle materials which might chip or splatter, or make the fastener ricochet.

An alignment guide must be used when shooting a fastener into an existing hole. A fastener must not be drive into a spalled area caused by an unsatisfactory fastening.

HYDRAULIC POWER TOOLS

The fluid used in hydraulic power tools must be an approved fire-resistant fluid and must retain its operating characteristics at the most extreme temperature to which it will be exposed.

The manufacturer's recommended safe operating pressure for hoses, valve, pipes, filters, and other fittings must not be exceeded.

JACKS

All jacks — level and rachel jacks, screw jacks, and hydraulic jacks — must have a device which stops them from jacking up to high. Also, the manufacturer's load limit

must be permanently marked in a prominent place on the jack and should not be exceeded.

A jack should never be used to support a lifted load. Once the load has been lifted, it must immediately be blocked up. Use wooden blocking under the base if necessary to make the jack level and secure. If the lift surface is metal, place a one-inch thick hardwood block or equivalent between it and the metal jack head to reduce the danger of slippage.

To set up a jack, be sure that

- The base rests on a firm level surface,
- The jack is correctly centered,
- The jack head bears against a level surface, and
- The lift force is applied squarely.

Proper maintenance of jacks is essential for safety. All jacks must be inspected before each use and lubricated regularly. If a jack is subjected to an abnormal load or shock, it should be thoroughly examined to make sure it has not been damaged.

jacks exposed to freezing temperatures must be filled with an adequate antifreeze liquid.

GENERAL SAFETY PRECAUTIONS

Employees using hand and power tools and exposed to the hazard of falling, flying, abrasive and splashing objects, or exposed to harmful dusts, fumes, mists, vapors, or gases must be provided with the particular personal equipment necessary to protect them from the hazard.

All hazards involved in the use of power tools can be prevented by following five basic safety rules:

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use.
- Operate according to the manufacturer's instructions.
- Provide and use the right protective equipment.

Employees and employers have a responsibility to work together to establish safe working procedures. If a hazardous situation is encountered, it should be brought to the attention of the proper individual immediately.

SOURCE: OSHA, 1986. Booklet No. 3080

I. CHEMICAL AGENTS

Zinc — Zinc is used in large quantities in the manufacture of brass, galvanized metals, and various other alloys. Inhalation of zinc oxide fumes can occur when welding or cutting on zinc-coated metals. Exposure to these fumes is known to cause metal fume fever. Symptoms of metal fume fever are very similar to those of common influenza. They include fever (rarely exceeding 102_ F), chills, nausea, dryness of the throat, cough, fatigue, and general weakness and aching of the head and body. The victim may sweat profusely for a few hours, after which the body temperature begins to return to normal. The symptoms of metal fume fever have rarely, if ever, lasted beyond 24 hours. The subject can then appear to be more susceptible to the onset of this condition on Mondays or on weekdays following a holiday than they are on other days.

Cadmium — Cadmium is used frequently as a rust-preventive coating on steel and also as an alloying element. Acute exposures to high concentrations or cadmium fumes can produce severe lung irritation, pulmonary edema, and in some cases, death. Long-term exposure to low levels of cadmium in air can result in emphysema (a disease affecting the ability of the lung to absorb oxygen) and can damage the kidneys.

Beryllium — Beryllium is sometimes used as an alloying element with copper and other base metals. Acute exposure to high concentrations of beryllium can result in chemical pneumonia. Long-term exposure can result in shortness of breath, chronic cough, and significant weight loss, accompanied by fatigue and general weakness.

Iron Oxide — Iron is the principal alloying element in steel manufacture. During the welding process, iron oxide fumes arise from both the base metal and the electrode. The primary acute effect of this exposure is irritation of nasal passages, throat, and lungs. Although long-term exposure to iron oxide fumes may result in iron pigmentation of the lungs, most authorities agree that these iron deposits in the lung are not dangerous.

Mercury — Mercury compounds are used to coat metals to prevent rust or inhibit foliage growth (marine paints). Under the intense heat of the arc or gas flame, mercury vapors will be produced. Exposure to these vapors may produce stomach pain, diarrhea, kidney damage, or respiratory failure. Long-term exposure may produce tremors, emotional instability, and hearing damage.

Lead — The welding and cutting of lead-bearing allows or metals whose surfaces have been painted with lead-based paint can generate lead oxide fumes. Inhalation and ingestion of lead oxide fumes and other lead compounds will cause lead poisoning. Symptoms include metallic taste in the mouth, loss of appetite, nausea, abdominal cramps, and insomnia. In time, anemia and general weakness, chiefly in the muscles of the wrists, develop. Lead adversely affects the brain, central nervous system, circulatory system, reproductive system, kidneys, and muscles.

Fluorides — Fluoride compounds are found in the coatings of several types of fluxes used in welding. Exposure to these fluxes may irritate the eyes, nose, and throat. repeated exposure to high concentrations of fluorides in air over a long period may cause pulmonary edema (fluid in the lungs) and bone damage. Exposure to fluoride dusts and fumes has also produced skin rashes.

Chlorinated Hydrocarbon Solvents — Various chlorinated hydrocarbons are used in degreasing or other cleaning operations. The vapors of these solvents are a concern in welding and cutting because the heat and ultraviolet radiation from the arc will decompose the vapors and form highly toxic and irritating phosgene gas. (See Phosgene)

Phosgene — Phosgene is formed by decomposition of chlorinated hydrocarbon solvents by ultraviolet radiation. It reacts with moisture in the lungs to produce hydrogen chloride, which in turn destroys lung tissue. For this reason, any use of chlorinated solvents should be well away from welding operations or any operation in which ultraviolet radiation or intense heat is generated.

Carbon Monoxide — Carbon monoxide is a gas usually formed by the incomplete combustion of various fuels. Welding and cutting may produce significant amounts of carbon monoxide. In addition, welding operations that use carbon dioxide as the inert gas shield may produce hazardous concentrations of carbon monoxide in poorly ventilated areas. This is caused by a "breakdown" of shielding gas. Carbon monoxide is odorless and colorless and cannot be detected. Common symptoms of overexposure include pounding of the heart, a dull headache, flashes before the eyes, dizziness, ringing in the ears, and nausea.

Nitrogen Oxides — The ultraviolet light of the arc can produce nitrogen oxides (NO,NO_2), from the nitrogen (N) and Oxygen (O_2) in the air. Nitrogen oxides are

produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GMAW or heli-arc), and plasma arc cutting. Even greater quantities are formed if the shielding gas contains nitrogen. Nitrogen dioxide (NO_2), one of the oxides formed, has the greatest health effect. This gas is irritating to the eyes, nose, and throat but dangerous concentrations can be inhaled without any immediate discomfort. High concentrations can cause shortness of breath, chest pain, and fluid in the lungs (pulmonary edema).

Ozone — Ozone (O_3) is produced by ultraviolet light from the welding arc. Ozone is produced in greater quantities by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GMAW or heli-arc), and plasma arc cutting. Ozone is a highly active form of oxygen and can cause great irritation to all mucous membranes. Symptoms of ozone exposure include headache, chest pain, and dryness of the upper respiratory tract. Excessive exposure can cause fluid in the lungs (pulmonary edema). Both nitrogen dioxide and ozone are thought to have long-term effects on the lungs.

II. PHYSICAL AGENTS

Ultraviolet Radiation — Ultraviolet radiation (UV) is generated by the electric arc in the welding process. Skin exposure to UV can result in severe burns, in many cases without prior warning. UV radiation can also damage the lens of the eye. Many arc welders are aware of the condition known as "arc-eye," a sensation of sand in the eyes. This condition is caused by excessive eye exposure to UV. Ultraviolet rays also increase the skin effects of some industrial chemicals (coal tar and cresol compounds, for example).

Infrared Radiation — Exposure to infrared radiation (IR), produced by the electric arc and other flame cutting equipment may heat the skin surface and the tissues immediately below the surface. Except for this effect, which can progress to thermal burns in some situations, infrared radiation is not dangerous to welders. Most welders protect themselves from IR (and UV) with a welder's helmet (or glasses) and protective clothing.

Intense Visible Light — Exposure of the human eye to intense visible light can produce adaptation, pupillary reflex, and shading of the eyes. Such actions are protective mechanisms to prevent excessive light from being focused on the retina. In the arc welding process, eye exposure to intense visible light is prevented for the most part by the welder's helmet. However, some individuals have sustained retinal damage due to

careless "viewing" of the arc. At no time should the arc be observed without eye protection.

FILTER LENS SHADE NUMBER GUIDE

Welding Operation	Shade Number
Shielded Metal-Arc Welding, up to 5/32" (4mm) electrodes	10
Shielded Metal-Arc Welding, 3/16 to 1/4" (4.8 to 6.5mm) electrodes	12
Shielded Metal-Arc Welding, over 1/4" (6.4mm) electrodes	14
Gas Metal-Arc Welding (Nonferrous)	11
Gas Metal-Arc Welding (Ferrous)	12
Gas Tungsten-Arc Welding	12
Atomic Hydrogen Welding	14
Carbon Arc Welding	10-14
Torch Soldering	2
Torch Brazing	3 or 4
Light Cutting, up to 1" (25mm)	3 or 4
Medium Cutting, 1" to 6" (25 to 150mm)	4 or 5
Heavy Cutting, over 6" (150mm)	5 or 6
Gas Welding (light), up to 1/8" (3.2mm)	4 or 5
Gas Welding (medium), 1/8" to 1/2" (3.2 to 12.7mm)	5 or 6
Gas Welding (heavy), over 1/2" in (12.7mm)	6 or 8

In gas welding or oxygen cutting where the torch produces a high yellow light, it is desirable to use a filter lens that absorbs the yellow or sodium line in the visible light of the operation spectrum.

SOURCE: OSHA

INTRODUCTION

Many welding and cutting operations require the use of compressed gases. When compressed gases are consumed in the welding process, such as oxygen-fuel gas welding, requirements for their handling, storage, and use are contained in 29 CFR, Subpart O.

General requirements for the handling, storage and use of compressed gases are contained in 29 CFR, Subpart H-Hazardous Materials, §§1910.101 - 1910.105. Certain welding and cutting operations require the use of compressed gases other than those consumed in the welding process. For example, gas metal arc welding utilizes compressed gases for shielding. Handling, storage, and use of compressed gases in situations such as these requires compliance with the requirements contained in 29 CFR, Subpart H.

Many hazards are involved in compressed gas handling, storage, and use. To understand these hazards, we must realize that compressed gases are stores of potential energy. It takes energy to compress and confine the gas. That energy is stored until purposely released to perform useful work or until accidental release by container failure or other causes.

Some compressed gases, for example, acetylene, have high flammability characteristics. Flammable compressed gases, therefore, have additional stored energy besides simple compression-release energy. Other compressed gases, such as nitrogen, have simple asphyxiating properties. Some compressed gases, such as oxygen, can augment or compound fire hazards.

COMPRESSED GASES

Cylinder Inspection — Employers shall determine that compressed gas cylinders under their control are in a safe condition to the extent that this can be determined by visual inspection. Visual and "other" inspections are required, but "other" inspections are not defined. These inspections must be conducted as prescribed in the Hazardous Materials Regulations of the Department of Transportation (DOT) contained in 49 CFR Parts 171-179 and 14 CFR Part 103. Where these regulations are not applicable, these inspections

shall be conducted in accordance with Compressed Gas Association (CGA) Pamphlets C-6 and C-8. According to DOT regulations:

> "A cylinder that leaks, is bulged, has defective valves or safety devices, bears evidence of physical abuse, fire or heat damage, or detrimental rusting or corrosion, must not be used unless it is properly repaired and requalified as prescribed in these regulations."

The term "cylinder" is defined as a pressure vessel designed for pressures higher than 40 psia (pounds per square inch absolute) and having a circular cross section. It does not include a portable tank, multiunit tank car tank, cargo tank, or tank car.

DOT requires basic information markings on all cylinders. Each required marking on a cylinder must be maintained so that it is legible.

Handling, Storage, and Utilization — The handling storage, and utilization of all compressed gases in cylinders, portable tanks, rail tankcars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association (CGA) Pamphlet P-1.

Safety Relief Devices — Compressed gas cylinders, portable tanks, and cargo tanks shall have pressure relief devices installed and maintained in accordance with CGA Pamphlets S-1.1 and S-1.2.

FIRE PREVENTION AND PROTECTION

Basic Precautions — The basic precautions for fire prevention in welding or cutting work are:

- If the object to be welded or cut cannot readily be moved, all movable fire hazards in the vicinity shall be taken to a safe place.

- If the object to be welded or cut cannot be moved and if all the fire hazards cannot be removed, then guards shall be used to confine the heat, sparks, and slag, and to protect the immovable fire hazards.

- If the above requirements cannot be met, then welding and cutting shall not be performed.

Special Precautions — Suitable fire extinguishing equipment shall be maintained in a state of readiness for instant use. Such equipment may consist of pails of water, buckets of sand, hose or portable extinguishers depending upon the nature and quantity of the combustible material exposed.

Fire watchers are required whenever welding or cutting is performed in locations where other than a minor fire might develop, or any of the following conditions exist:

- Appreciable combustible materials, in building construction or contents, closer than 35 feet to the point of operation.

- Appreciable combustibles more than 35 feet away but are easily ignited by sparks.

A fire watch shall be maintained for at least a half hour after completion of welding or cutting operations to detect and extinguish possible smoldering fires.

Cutting or welding shall not be permitted in e following situations:

- In areas not authorized by management

- In sprinklered buildings while such protection is impaired

- In the presence of explosive atmospheres (mixtures of flammable gases, vapors, liquids, or dusts with air), or explosive atmospheres that may develop inside uncleaned or improperly prepared tanks or equipment which have previously contained such materials, or that may develop in areas with an accumulation of combustible dusts.

Welding or Cutting Containers — No welding, cutting, or other hot work shall be performed on used drums, barrels, tanks, or other containers until they have been cleaned so thoroughly as to make absolutely certain that there are no flammable materials present or any substances such as greases, tars, acids, or other materials which when subjected to heat, might produce flammable or toxic vapors. Any pipe lines or connections to the drum or vessel shall be disconnected or blanked.

Confined Spaces — When arc welding is to be suspended for any substantial period of time, such as during lunch or overnight, all electrodes shall be removed from the holders and the holders carefully located so that accidental contact cannot occur and the machine shall be disconnected from the power source.

In order to eliminate the possibility of gas escaping through leaks or improperly closed valves, when gas welding or cutting, the torch valves shall be closed and the gas supply to the torch positively shut off at some point outside the confined area whenever the torch is not to be used for a substantial period of time, such as during lunch hour or overnight. Where practicable, the torch and hose shall also be removed from the confined space.

PROTECTION OF PERSONNEL

General — A welder or helper working on platforms, scaffolds, or runways shall be protected against falling through the use of railings, safety belts, life lines, or some equally effective safeguards.

Eye Protection — Helmets or hand shields shall be used during all arc welding or arc cutting operations, excluding submerged arc welding. Helpers or attendants shall be provided with proper eye protection.

Helmets and hand shields shall be made of a material which is in insulator for heat and electricity. Helmets, shields and goggles shall not be readily flammable and shall be capable of withstanding sterilization.

Helmets and hand shields shall be arranged to protect the face, neck, and ears from direct radiant energy from the arc.

Where the work permits, the welder should be enclosed in an individual booth painted with a finish of low reflectivity such as zinc oxide (an important factor for absorbing ultra-violet radiations) and lamp black, or shall be enclosed with non-combustible screens similarly painted. Booths and screens shall permit circulation of air at floor level. Workers or other persons adjacent to the welding areas shall be protected from the rays by non-combustible or flameproof screens or shields or shall be required to wear appropriate goggles.

Protective Clothing — Employees exposed to the hazards created by welding, cutting, or brazing operations shall be protected by personal protective equipment in accordance with the requirements of §1910.132. Appropriate protective clothing required for any welding operation will vary with the size, nature, and location of the work to be performed. Welders should always select clothing materials which will provide maximum protection from sparks and hot metal. Protective eyewear, safety shoes, clean, fire-resistant clothing, and fire-resistant gauntlet gloves are recommended. Additionally, the shirt should have full sleeves, no pockets, and should be worn outside the trousers with collar buttoned. The trousers should have no cuffs and should extend well down to the safety shoes.

Work in Confined Spaces — A confined space is defined in this regulation to be a relatively small or restricted space such as a tank, boiler, pressure vessel, or small compartment of a ship.

Adequate ventilation is a prerequisite to work in confined spaces. Ventilation requirements are discussed later in this section.

When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside.

Where welders must enter a confined space through a manhole or other small opening, means shall be provided for quickly removing them in case of emergency. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

When arc welding is to be suspended for any substantial period of time, such as during lunch or overnight, all electrodes shall be removed from the holders and the holders carefully located so that accidental contact cannot occur and the machine disconnected from the power source.

In order to eliminate the possibility of gas escaping through leaks of improperly closed valves, when gas welding or cutting, the torch valves shall be closed and the fuel-gas and oxygen supply to the torch positively shut off at some point outside the confined area whenever the torch is not to be used for a substantial period of time, such as during lunch or overnight. Where practicable, the torch and hose shall also be removed from the confined space.

HEALTH PROTECTION AND VENTILATION

Mechanical ventilation is required when welding or cutting is done with materials not specifically mentioned in this section. These materials - fluorine compounds, zinc, lead, beryllium, cadmium, mercury, cleaning compounds, and stainless steel are particularly hazardous and have specific control requirements.

SOURCE: OSHA

CONTROLLING ELECTRICAL HAZARDS

INTRODUCTION

Electricity has become an essential of modern life, both at home and on the job. Some employees work with electricity directly, as is the case with engineers, electricians, or people who do wiring, such as overhead lines, cable harnesses, or circuit assemblies. Others, such as office workers and salespeople, work with it indirectly. As a source of power, electricity is accepted without much thought to the hazards encountered. Perhaps because it has become such a familiar part of our surroundings, it often is not treated with the respect it deserves.

For 1980, the Bureau of Labor Statistics reports that 4,400 work-connected deaths occurred in private sector workplaces employing 11 workers or more. The total number of job-related injuries for that same period was roughly 5.5 million. One-tenth of one percent of all accidents, or about 2,500 injuries, were due to various degrees of electrical shock. Eight percent of the fatalities, or around 350 deaths, were the direct result of electrocutions at work. What makes these statistics more tragic is that, for the most part, these accidents and fatalities could have been easily avoided.

How Does Electricity Act?

To handle electricity safely, it is necessary to understand how it acts, how it can be directed, what hazards it presents, and how these hazards can be controlled. For this purpose it is helpful to compare the flow of electricity with the flow of water.

Operating an electrical switch may be considered analogous to turning on a water faucet. Back of the faucet or the switch there must be a source of water or electricity, with something in which to transport it, and with pressure to make it flow. In the case of water, the source is a reservoir or pumping station; the transportation is through pipes; and the force to make it flow is pressure, provided by a pump. In electricity, the source is the power generating station; current travels (is transported) through electrical conductors in the form of wires; and pressure, measured in volts, is provided by a generator.

Resistance to the flow of electricity is measured in ohms and varies widely. It is determined by three factors: the nature of the substance itself; the length and cross-sectional area (size) of the substance; and the temperature of the substance.

Some substances, such as metals, offer very little resistance to the flow of electrical current and are called conductors. Other substances, such as bakelite, porcelain, pottery, and dry wood, offer such a high resistance that they can be used to prevent the flow of electrical current and are called insulators.

Dry wood has a high resistance, but when saturated with water its resistance drops to the point where it will readily conduct electricity. The same thing is true of human skin. When it is dry, skin has a fairly high resistance to electrical current; but when it is moist, there is a radical drop in resistance. Pure water is a poor conductor, but small amounts of impurities, such as salt and/or acid (both of which are contained in perspiration), make it a ready conductor. Therefore, when water is present either in the environment or on the skin, anyone working with electricity should exercise even more caution than they normally would.

How Shocks Occur

Electricity travels in closed circuits, and its normal route is through a conductor. Shock occurs when the body becomes a part of the electrical circuit. The current must enter the body at one point and leave at another. Shock normally occurs in one of three ways. The person must come in contact with: both wires of the electrical circuit; one wire of an energized circuit and the ground; or a metallic part that has become "hot" by being in contact with an energized wire, while the person is also in contact with the ground.

The metal parts of electrical tools and machines may become "hot" if there is a break in the insulation of the tool or machine wiring. The worker using these tools and machines is made less vulnerable to electrical shock when a low-resistance path from the metallic case of the tool or machine to the ground is established. This is done through the use of an equipment grounding conductor—a low-resistance wire that causes the unwanted current to pass directly to the ground rather than through the body of the person in contact with the tool or machine. If the equipment grounding conductor has been properly installed, it has a low resistance to ground, and the worker is being protected.

Severity of the Shock

The severity of the shock received when a person becomes a part of an electrical circuit is affected by three primary factors: the amount of current flowing through the body (measured in amperes); the path of the current through the body; and the length of time the body is in the circuit. Other factors which may affect the severity of shock are the frequency of the current, the phase of the heart cycle when shock occurs, and the general health of the person prior to shock.

The effects from electric shock depend upon the type of circuit, its voltage, resistance, amperage, pathway through the body, and duration of the contact. Effects can range from a barely perceptible tingle to immediate cardiac arrest. Although there are no absolute limits or even known values which show the exact injury from any given amperage, the following table shows the general relationship between the degree of injury and amount of amperage for a 60-cycle hand-to-foot path of one second's duration of shock.

EFFECTS OF ELECTRICAL CURRENT IN THE HUMAN BODY

Current	Reaction
1 Milliampere	Perception level. Just a faint tingle.
5 Milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range can lead to injuries.
6-25 Milliamperes (women) 9-30 Milliamperes (men)	Painful shock, muscular control is lost. This is called the freezing current or "let-go" range.
50-150 Milliamperes	Extreme pain, respiratory arrest, severe muscular contractions[a]. Individual cannot let go. Death is possible.
1,000-4300 Milliamperes	Ventricular fibrillation. (The rhythmic pumping action of the heart ceases.) Muscular contraction and nerve damage occur. Death is most likely.
10,000 Milliamperes	Cardiac arrest, severe burns and probable death.

(a) If the extensor muscles are excited by the shock, the person may be thrown away from the circuit.

As this table illustrates, a difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill. Muscular contraction caused by stimulation may not allow the victim to free himself/herself from the circuit, and the increased duration of exposure increases the dangers to the shock victim. For example, a current of 100 milliamperes for 3 seconds is equivalent to a current of 900 milliamperes applied for .03 seconds in causing fibrillation. The so-called low voltages can be extremely dangerous because, all other factors being equal, the degree of injury is proportional to the length of time the body is in the circuit. LOW VOLTAGE DOES NOT IMPLY LOW HAZARD.

Burns and Other Injuries

A severe shock can cause considerably more damage to the body than is visible. There may be internal hemorrhages and destruction of tissues, nerves, and muscles. In addition, shock is often only the beginning in a chain of events. The final injury may well be from a fall, cuts, burns, or broken bones.

The most common shock-related injury is a burn. Burns suffered in electrical accidents may be of three types: electrical burns, arc burns, and thermal contact burns.

Electrical burns are a result of the electrical current flowing through tissues or bones. Tissue damage is caused by the heat generated by the current flow through the body. Electrical burns are one of the most serious injuries you can receive and should be given immediate attention.

Arc or flash burns, on the other hand, are the result of high temperatures in close proximity to the body and are produced by an electric arc or explosion. They should be attended to promptly.

Finally, thermal contact burns are those normally experienced when the skin comes in contact with hot surfaces of overheated electrical conductors, conduits, or other energized equipment. Additionally, clothing may be ignited in an electrical accident and a thermal burn will result. All three types of burns may be produced simultaneously.

Electric shock can also cause injuries of an indirect or secondary nature in which involuntary muscle reaction from the electric shock can cause bruises, bone fractures,

and even death resulting from collisions or falls. In some cases, injuries caused by electric shock can be a contributory cause of delayed fatalities.

In addition to shock and burn hazards, electricity poses other dangers. For example, when a short circuit occurs, hazards are created from the resulting arcs. If high current is involved, these arcs can cause injury or start a fire. Extremely high-energy arcs can damage equipment, causing fragmented metal to fly in all directions. Even low-energy arcs can cause violent explosions in atmospheres which contain explosive gases, vapors, or combustible dusts.

Correcting Electrical Hazards

Electrical accidents appear to be caused by a combination of three possible factors—unsafe equipment and/or installation, workplaces made unsafe by the environment, and unsafe work practices by employees. There are various ways of protecting people from the hazards caused by electricity. These include; insulation, guarding, grounding, mechanical devices, and safe work practices.

Insulation—One way to safeguard individuals from electrically energized wires and parts is through insulation. An insulator is any material with high resistance to electrical current. Insulators—such as glass, mica, rubber, and plastic—are put on conductors to prevent shock, fires, and short circuits. Before employees prepare to work with electrical equipment, it is always a good idea for them to check the insulation before making a connection to a power source to be sure there are no exposed wires. The insulation of electrical cords, such as extension cords, is particularly vulnerable to damage.

The insulation that covers conductors is regulated by Subpart S of 29 CFR Part 1910, "Design Safety Standards for Electrical Systems," as published in the *Federal Register* on January 16, 1981. This standard revises the former Subpart S and places relevant requirements of the National Electrical Code (NEC) directly into the text of the regulations, making it unnecessary for employees to refer to the NEC to determine their obligations and unnecessary for OSHA to continue incorporating the NEC by reference.

The standard generally requires that circuit conductors, the material through which current flows, be insulated to prevent people from coming into accidental contact with the current. Also, the insulation should be suitable for the voltage and existing

conditions, such as temperature, moisture, oil, gasoline, or corrosive fumes. All these factors must be evaluated before the proper choice of insulation can be made.

Conductors and cables are marked by the manufacturer to show the maximum voltage and American Wire Gage size, the type letter of the insulation, and the manufacturer's name or trademark.

Insulation is often color coded. In general, insulated wires used as equipment grounding conductors are either continuous green or green with yellow stripes. The grounded conductors which complete a circuit are generally covered with continuous white or natural gray-colored insulation. The ungrounded conductors, or "hot wires," may be any color other than green, white, or gray. They are often colored black or red.

Guarding—Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Guarding of live parts may be accomplished by:

- Location in a room, vault, or similar enclosure accessible only to qualified persons
- Use of permanent, substantial partitions or screens to exclude unqualified persons
- Location on a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons, or
- Elevation of 8 feet or more above the floor.

Entrances to rooms and other guarded locations containing exposed live parts must be marked with conspicuous warning signs forbidding unqualified persons to enter.

Indoor electric installations that are over 600 volts and that are open to unqualified persons must be made with metal-enclosed equipment or enclosed in a vault or area controlled by a lock. In addition, equipment must be marked with appropriate caution signs.

Grounding—Grounding is another method of protecting employees from electric shock; however, it is normally a secondary protective measure. The term "ground" refers to a

conductive body, usually the earth. Used as a noun, the term means a conductive connection, whether intentional or accidental, by which an electrical circuit or equipment is connected to earth or ground plane. By "grounding" a tool or electrical system, a low-resistance path to the earth through a ground connection or connections has been intentionally created. When properly done, this path offers sufficiently low resistance and has sufficient current-carrying capacity to prevent the buildup of voltages which may result in a personnel hazard. This does not guarantee that no one will receive a shock, be injured, or be killed. However, it substantially reduces the possibilities of such accidents—especially when used in combination with the other safety measures discussed in this booklet.

There are two kinds of grounds required by "Design Safety Standards for Electrical Systems" (Subpart S). One of these is called the "service or system ground." In this instance, one wire—called "the neutral conductor" or "grounded conductor"—is grounded. In an ordinary low-voltage circuit, the white (or gray) wire is grounded at the generator or transformer and again at the service entrance to the building. This type of ground is primarily designed to protect machines, tools, and insulation against damage.

To offer enhanced protection to the workers themselves, an additional ground, sometimes called the "equipment ground," must be furnished by providing another path from the tool or machine through which the current can flow to the ground. This additional ground safeguards the electrical equipment operator in the event that a malfunction causes the metal frame of the tool to become accidentally energized. The resulting heavy surge of current will then activate the circuit of protection and open the circuit.

Mechanical Devices—Mechanical devices are designed to automatically limit or shut off the flow of electricity in the event of a ground-fault, overload, or short circuit in the wiring system. Fuses, circuit breakers, and ground-fault circuit interrupters are three well known examples of such devices.

Fuses and circuit-breakers are over-current devices which are placed in circuits to monitor the amount of current the circuit will carry. They automatically open or break the circuit when the amount of current flow becomes excessive and therefore unsafe. Fuses are designed to melt when too much current flows through them. Circuit breakers, on the other hand, are designed to trip open the circuit.

Fuses and circuit breakers are intended primarily for the protection of conductors and equipment. They prevent overheating of wires and components which might otherwise create hazards for other operators. They also open the circuit under certain hazardous ground-fault conditions.

The ground-fault circuit interrupter of GFCI is designed to shut off electrical power within as little as 1/40 of a second. It works by comparing the amount of current going to an electrical device against the amount of current returning from the device along the circuit conductors. The GFCI is used in high-risk areas such as wet locations and construction sites.

Safe Work Practices—Employees and others working with electrical equipment need to use safe work practices. These include: de-energizing electrical equipment before inspecting or making repairs, using electrical tools that are in good repair, using good judgment when working near energized lines, and using appropriate protective equipment.

De-energizing Electrical Equipment. The accidental or unexpected sudden starting of electrical equipment can cause severe injury or death. Before ANY inspections or repairs are made—even on the so-called low-voltage circuits—the current should be turned off at the switch box and the switch be padlocked in the OFF position. At the same time the switch or controls of the machine or other equipment being locked out of service should be securely tagged to show which equipment or circuits are being worked on.

Maintenance employees should be qualified electricians who have been well instructed in lockout procedures. No two locks should be alike; each key should fit only one lock, and only one key should be issued to each maintenance employee. If more than one employee is repairing a piece of equipment, each should lock out the switch with his or her own lock and never permit anyone else to remove it. The maintenance worker should at all times be certain that he or she is not exposing other employees to danger.

Tools. To minimize his or her own safety, an employee should always be sure to use tools that are working properly. Tools should be inspected frequently, and those found questionable, removed from service and properly tagged. Tools and other equipment should be regularly maintained. Inadequate maintenance can cause equipment to deteriorate, resulting in an unsafe condition.

Good Judgment. Perhaps the single most successful defense against electrical accidents is the continuous exercising of good judgment or common sense. All employees should be thoroughly familiar with the safety procedures for their particular jobs. When working around energized lines, for example, some basic procedures are: (1) have the line de-energized, (2) ensure that the line remains de-energized by using some type of lockout/tagging procedure, (3) use insulated work equipment, and (4) keep a safe distance from energized lines.

Protective Equipment. Employees whose occupations require them to work constantly and directly with electricity must use the personal protective equipment required for the jobs they perform. This equipment may consist of rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets.

CONCLUSION

The control of electrical hazards is an important part of every safety and health program. The responsibility for this program should be delegated to individuals who have a complete knowledge of electricity, electrical work practices, and the appropriate OSHA standards for installation and performance.

Everyone has the right to work in a safe environment. Through cooperative efforts, employers and employees can learn to identify and eliminate or control electrical hazards.

SOURCE: OSHA, 1991. Booklet No. 3075

Insulation and Grounding

Insulation and grounding are two recognized means of preventing injury during electrical equipment operation. Conductor insulation may be provided by placing nonconductive material such as plastic around the conductor. Grounding may be achieved through the use of a direct connection to a known ground such as a metal cold water pipe.

Consider, for example, the metal housing or enclosure around a motor or the metal box in which electrical switches, circuit breakers, and controls are placed. Such enclosures protect the equipment from dirt and moisture and prevent accidental contact with exposed wiring. However, there is a hazard associated with housing and enclosures. A malfunction within the equipment—such as deteriorated insulation—may create an electrical shock hazard. Many metal enclosures are connected to a ground to eliminate the hazard. If a "hot" wire contacts a grounded enclosures, a ground fault results which normally will trip a circuit breaker or blow a fuse. Metal enclosures and containers are usually grounded by connecting them with a wire going to ground. This wire is called an equipment grounding conductor. Most portable electric tools and appliances are grounded by this means. There is one disadvantage to grounding: a break in the grounding system may occur without the user's knowledge.

Insulation may be damaged by hard usage on the job or simply by aging. If this damage causes the conductors to become exposed, the hazards of shocks, burns, and fire will exist. Double insulation may be used as additional protection on the live parts of a tool, but double insulation does not provide protection against defective cords and plugs or against heavy moisture conditions.

The use of a ground-fault circuit interrupter (GFCI) is one method used to overcome grounding and insulation deficiencies.

What is a GFCI?

The GFCI is a fast-acting circuit breaker which senses small imbalances in the circuit caused by current leakage to ground and, in a fraction of a second, shuts off the electricity. The GFCI continually matches the amount of current going to an electrical device against the amount of current returning from the device along the electrical path.

Whenever the amount "going" differs from the amount "returning" by approximately 4 milliamps, the GFCI interrupts the electric power within as little as 1/40 of a second.

However, the GFCI will not protect the employee from line-to-line contact hazards (such as a person holding two "hot" wires or a hot and a neutral wire in each hand). It does provide protection against the most common form of electrical shock hazard—the ground fault. It also provides protection against fires, overheating, and destruction of insulation on wiring.

What Are the Hazards?

With the wide use of portable tools on construction sites, the use of flexible cords often becomes necessary. Hazards are created when cords, cord connectors, receptacles, and cord- and plug-connected equipment are improperly used and maintained.

Generally, flexible cords are more vulnerable to damage than is fixed wiring. Flexible cords must be connected to devices and to fittings so as to prevent tension at joints and terminal screws. Because a cord is exposed, flexible, and unsecured, joints and terminals become more vulnerable. Flexible cord conductors are finely stranded for flexibility, but the strands of one conductor may loosen from under terminal screws and touch another conductor, especially if the cord is subjected to stress or strain.

A flexible cord may be damaged by activities on the job, by door or window edges, by staples or fastenings, by abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire. A frequent hazard on a construction site is a cord assembly with improperly connected terminals.

When a cord connector is wet, hazardous leakage can occur to the equipment grounding conductor and to humans who pick up that connector if they also provide a path to ground. Such leakage is not limited to the face of the connector but also develops at any wetted portion of it.

When the leakage current of tools is below 1 ampere, and the grounding conductor has a low resistance, no shock should be perceived. However, should the resistance of the equipment grounding conductor increase, the current through the body also will increase.

Thus, if the resistance of the equipment grounding conductor is significantly greater than 1 ohm, tools with even small leakages become hazardous.

Preventing and Eliminating Hazards

GFCIs can be used successfully to reduce electrical hazards on construction sites. Tripping of GFCIs—interruption of current flow—is sometimes caused by wet connectors and tools. It is good practice to limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors. Providing more GFCIs or shorter circuits can prevent tripping caused by the cumulative leakage from several tools or by leakages from extremely long circuits.

Employer's Responsibility—OSHA ground-fault protection rules and regulations have been determined necessary and appropriate for employee safety and health. Therefore, it is the employer's responsibility to provide either: (a) ground-fault circuit interrupters on construction sites for receptacle outlets in use and not part of the permanent wiring of the building or structure; or (b) a scheduled and recorded assured equipment grounding conductor program on construction sites, covering all cord sets, receptacles which are not part of the permanent wiring of the building or structure, and equipment connected by cord and plug which are available for use or used by employees.

Ground-Fault Circuit Interrupters—The employer is required to provide approved ground-fault circuit interrupters for all 120-volt, single phase, 15 and 20 ampere receptacle outlets on construction sites which are not a part of the permanent wiring of the building or structure and which are in use by employees. Receptacles on the ends of extension cords are not part of the permanent wiring and, therefore, must be protected by GFCIs whether or not the extension cord is plugged into permanent wiring. These GFCIs monitor the current-to-the-load for leakage to ground. When this leakage exceeds 5 mA ± 1 mA, the GFCI interrupts the current. They are rated to trip quickly enough to prevent electrocution. This protection is required in addition to, not as a substitute for, the grounding requirements of OSHA safety and health rules and regulations, 29 CFR 1926. The requirements which the employer must meet, if he or she chooses the GFCI option, are stated in 29 CFR 1926. 404(b)(1)(ii).

Assured Equipment Grounding Conductor Program—The assured equipment grounding conductor program covers all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and equipment connected by cord and plug

which are available for use or used by employees. The requirements which the program must meet are stated in 29 CFR 1926.404(b)(1)(iii), but employers may provide additional tests or procedures. OSHA requires that a written description of the employer's assured equipment grounding conductor program, including the specific procedures adopted. be kept at the jobsite. This program should outline the employer's specific procedures for the required equipment inspections, tests, and test schedule.

The required tests must be recorded, and the record maintained until replaced by a more current record. The written program description and the recorded tests must be made available, at the jobsite, to OSHA and to any affected employee upon request. The employer is required to designate one or more competent persons to implement the program.

Electrical equipment noted in the assured equipment grounding conductor program must be visually inspected for damage or defects before each day's use. Any damaged or defective equipment must not be used by the employee until repaired.

Two tests are required by OSHA. One is a continuity test to ensure that the equipment grounding conductor is electrically continuous. It must be performed on all cord sets, receptacles which are not part of the permanent wiring of the building or structure, and on cord- and plug-connected equipment which are required to be grounded. This test may be performed using a simple continuity tester, such as a lamp and battery, a bell and battery, an ohmmeter, or a receptacle tester.

The other test must be performed on receptacles and plugs to ensure that the equipment grounding conductor is connected to its proper terminal. This test can be performed with the same equipment used in the first test.

These tests are required before first use, after any repairs, after damage is suspected to have occurred, and at 3-month intervals. Cord sets and receptacles which are essentially fixed and not exposed to damage must be tested at 6-month intervals. Any equipment which fails to pass the required tests shall not be made available for or used by employees.

SUMMARY

Following these rules and regulations will help reduce the number of injuries and accidents from electrical hazards. Work disruptions should be minor, and the necessary inspections and maintenance should require little time.

SOURCE: OSHA, 1987. Booklet No. 3007